UM10025

XenD106L User Manual

Rev.1.0 **User Manual**

Introduction

This document introduces the battery-operated ultra-low energy human presence detection mmWave sensor XenD106L, including its basic functions, hardware specification, software configuration, installing condition, etc.

This document aims to guide users to get started with XenD106L ultra-low energy human presence detection mmWave sensor quickly and easily, so that users can sort out suitable parameters for specified scenarios, and can design high performance customized ultra-low energy human detection sensors.

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1. XenD106L Overview

XenD106L is a battery-operated ultra-low energy human presence detection mmWave sensor of ICLM EZ Sensor series. It contains a minimalist 24 GHz radar sensor hardware Xen106 and an intelligent low energy human presence detection algorithm firmware.

Hardware Xen106 incorporates an AIoT mmWave sensor SoC ICL1112[1], high-performance 24 GHz 1T1R antennas, and peripheral circuits. The low energy smart human detection algorithm can precisely detect moving, micro-moving and motionless standing human target by adopting the mmWave radar range measurement technology and ICL1112 specified signal processing and low energy control technology. The low energy human presence detection firmware is mainly applied to indoors scenarios for detecting moving and motionless human in the specified range and reporting results in real time with low energy consumption.

XenD106L can detect moving human target as far as 8 m. It enables users to flexibly adjust the detection range, trigger and hold detection thresholds, report frequency of human target status and distance, and absence report delay with the visualization tool. XenD106L supports both GPIO and UART interfaces and supports Plug and Play, and it can be applied flexibly to different scenarios and end products.

The main features of XenD106L are listed below:

- Integrate single chip smart mmWave sensor SoC and intelligent algorithm firmware
- Minimalist sensor size: 20 mm × 20 mm
- Load default setting of life presence detection, support Plug and Play
- 24 GHz ISM band frequency, FCC, CE, and SRRC compliant
- 3.3 V power supply, support a wide voltage range of 3.0 V~3.6 V
- Average operating current 0.1 mA @ 1 Hz report frequency
- Detect moving, micro-moving and motionless human body
- Report detection results in real time
- Provide a visualization tool, support configuring detection range and absence report delay
- Support detection range partition, totally block interference from outside area
- Detect as near as 0.2 m, no detection blind area
- Moving human detectable range up to 8 m
- Wide FOV of azimuth ±60° when wall-mounted
- Wall-mounted
- Support IAP function

XenD106L battery-operated ultra-low energy human presence detection mmWave sensor can detect moving and relaxed standing motionless human, and can be widely applied to various AIoT scenarios, including:

- **Smart Home**

  Detecting the human presence, reporting results in real time, enabling the MCU to control smart domestic appliances accordingly.

- **Smart Business**

  Detecting human approach or leaving in the specified range to turn on/off devices, keeping devices on when human presence is detected.

- **Intelligent Security**

  Intelligent lock, smart entrance control, building intercom, visual doorbell and so on.

- **Intelligent Lighting**

  Detecting human presence and location precisely, applicable to public lighting (LED bulbs, etc.)

[1] The hardware Xen106 adopts ICLM mmWave sensor SoC ICL1112, whose name used to be S3KM1112; due to the variation of production batch, the print screen of both names can be seen on the SoC.

2. System Characteristics

XenD106L is a battery-operated ultra-low energy human presence detection mmWave sensor developed based on ICLM mmWave sensor SoC ICL1112. It detects human body in the specified range and reports the results in real time by adopting FMCW and incorporating radar signal processing with the built-in low energy human detection algorithm. With this mmWave sensor reference solution, users can develop precise and low energy human detection products conveniently.

The hardware Xen106 consists of a fully integrated ICLM smart mmWave sensor SoC ICL1112, high-performance 24 GHz 1T1R antennas, and MCU. Incorporated with the low energy human presence detection firmware and a visualization tool, XenD106L enables users to flexibly adjust the detection range, trigger and hold threshold of different range gate, absence report delay, and sensor report frequency.

The characteristics of XenD106L are shown in Table 2-1.

Table 2-1 XenD106L characteristics

Parameter	Min.	Typ.	Max.	Unit	Condition
Hardware Xen106 Characteristics					
Supporting frequency	24	-	24.25	GHz	FCC, CE, and SRRC compliant
Max. bandwidth	-	0.25	-	GHz	-
Max. EIRP	-	10	-	dBm	-
Power supply	3.0	3.3	3.6	V	-
Size	-	20 × 20	-	mm^2	-
Environment temperature	-40	-	85	℃	-
XenD106L System Characteristics					
Detection range (Wall-mounted at 1.5 m)	-	8	-	m	Moving human detection
	-	4	-	m	Motionless human detection
Average operating current	-	0.1	-	mA	Office scenarios
Data report cycle	-	2	-	s	Adjustable

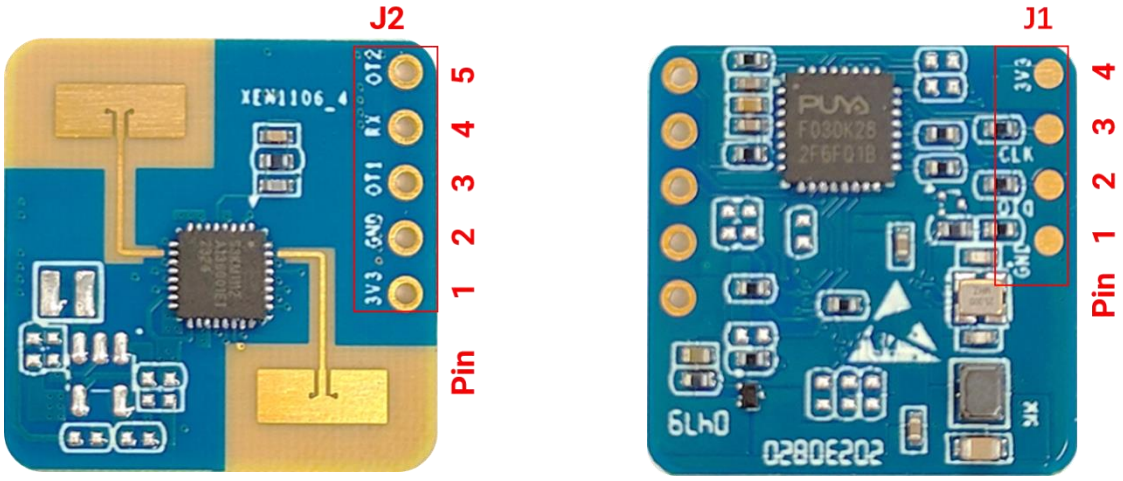
3. Hardware Overview

This chapter introduces hardware Xen106 and two compatible battery power supply boards.

3.1 Hardware Xen106

Device maps of hardware Xen106[2] are shown in Figure 3-1. Hardware Xen106 reserves 5 pins (default without contact pin) called J2 for power supply and communication; J1 pins as SWD interface for programming and debugging the MCU.

[2] Sensor hardware Xen106 used to be named as Xen1106; due to the variation of production batch, the print screen on the hardware could be either XEN1106_4 or XEN106.



(a) Top (b) Bottom

Figure 3-1 Top and bottom device map of hardware Xen106

Details of J1 and J2 pins are listed in Table 3-1 and Table 3-2.

Table 3-1 J1 pin description

J#PIN#	Name	Function	Operating Range
J1 Pin1	GND	Ground	-
J1 Pin2	DIO	SWD data port	0~3.3 V
J1 Pin3	CLK	SWD clock signal	0~3.3 V
J1 Pin4	3V3	Power input	3.0 V~3.6 V, Typ. 3.3 V

Table 3-2 J2 pin description

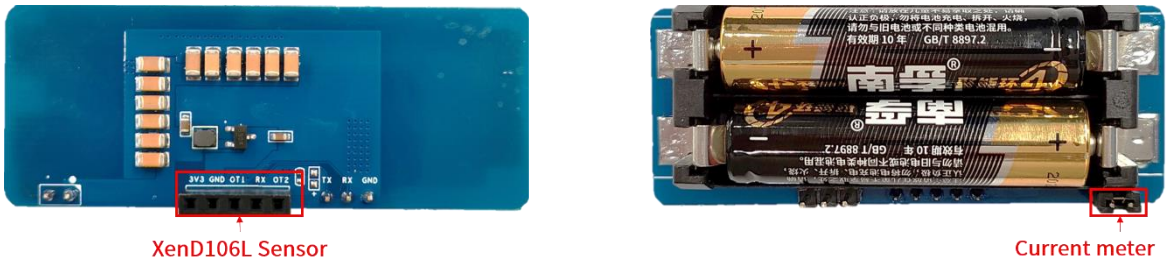
J#PIN#	Name	Function	Operating Range
J2 Pin1	3V3	Power input	3.0 V~3.6 V, Typ. 3.3 V
J2 Pin2	GND	Ground	-
J2 Pin3	OT1	UART_TX.	0~3.3 V
J2 Pin4	RX	UART_RX	0~3.3 V
J2 Pin5	OT2	IO, report detection results: high level means a target is detected, low level means no target is detected.	0~3.3 V

XenD106L supports Keil5 IDE programming, and either a hex or a bin firmware file is acceptable. Users can program hardware Xen106 using programmers such as J-Link (V9 or later version) and CMSIS-DAP. Please ensure the MCU driver is installed: Puya.PY32F0xx_DFP.1.2.0.pack.

3.2 Battery Power Supply Board

There are two types of battery power supply boards that support sensor operating current measurement for Sensor XenD106L. Developers can measure the operating current by connecting a high-precision multimeter or a current meter to the power supply board.

Figure 3-2 and Figure 3-3 present the device maps of a AAA battery power supply board and a button battery (CR2450) power supply board respectively. On each power supply board, there is a jumper cap to which the multimeter or current meter can connect for measuring the current.



(a) top (b) bottom

Figure 3-2 Device map of AAA battery power supply board

(a) top (b) bottom

Figure 3-3 Device map of button battery power supply board

4. Software Overview

This chapter introduces how to debug XenD106L firmware, and how to use the visualization tool. When debugging the sensor or using the visualization tool, either a host PC or a battery can be used to provide power for the sensor; meanwhile, ensure the TX, RX, and GND pins of the sensor or the battery board are connected to corresponding pins of the USB serial board.

XenD106L is released with the low energy human presence detection firmware programmed into the system, the firmware version is available on the external package of the sensor. ICLM provides a visualization software tool to configure XenD106L from a host PC, users can optimize the detection results by adjusting parameters according to the applied scenarios.

4.1 Firmware Description

This section introduces how to debug XenD106L firmware with a third-party serial port tool.

Step 1: Connect the sensor with the host PC using a USB-TTL serial transfer board; the connection of pins is listed in Table 4-1 and illustrated in Figure 4-1.

Table 4-1 Mapping pattern of pins

mmWave Sensor	USB Serial Board
RX	TXD
OT1	RXD
GND	GND
3V3	VCCIO

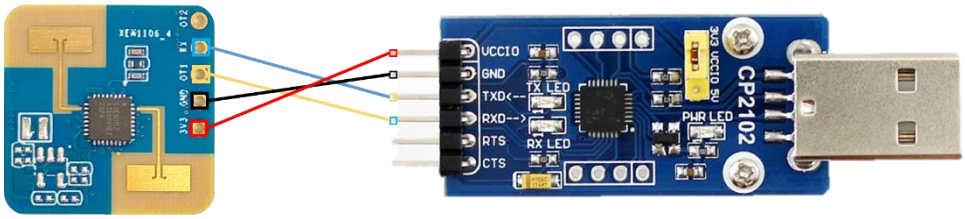


Figure 4-1 Connection between hardware Xen106 and USB serial board

Step 2: Open the **Device Manager** of the host PC, obtain the serial COM number of the sensor.

Step 3: Open the third-party serial port tool, select the sensor serial COM number, set the baud rate as 921600, click the **Open Serial Port** (or a similar) button, then the sensor detection results will show up on debugging tool console.

4.2 Visualization Tool Description

This section introduces how to use the visualization tool of XenD106L, and helps users to understand the meaning of relevant parameters, as well as how to determine their values.

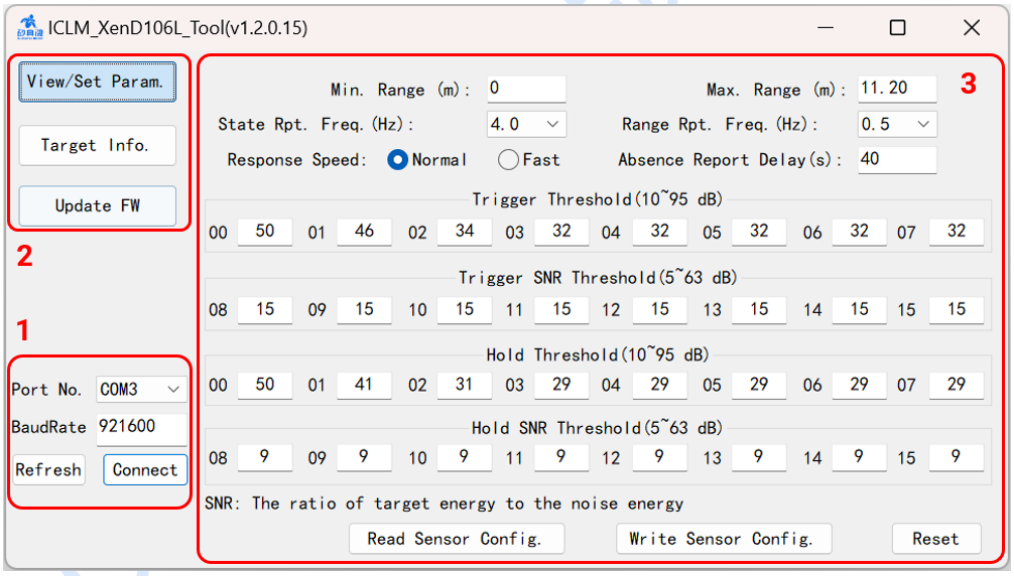
Note: The third-party serial port tool and the visualization tool cannot be used at the same time!

Users should connect the sensor with the visualization tool before applying the functions of the visualization tool, and the steps are as follows:

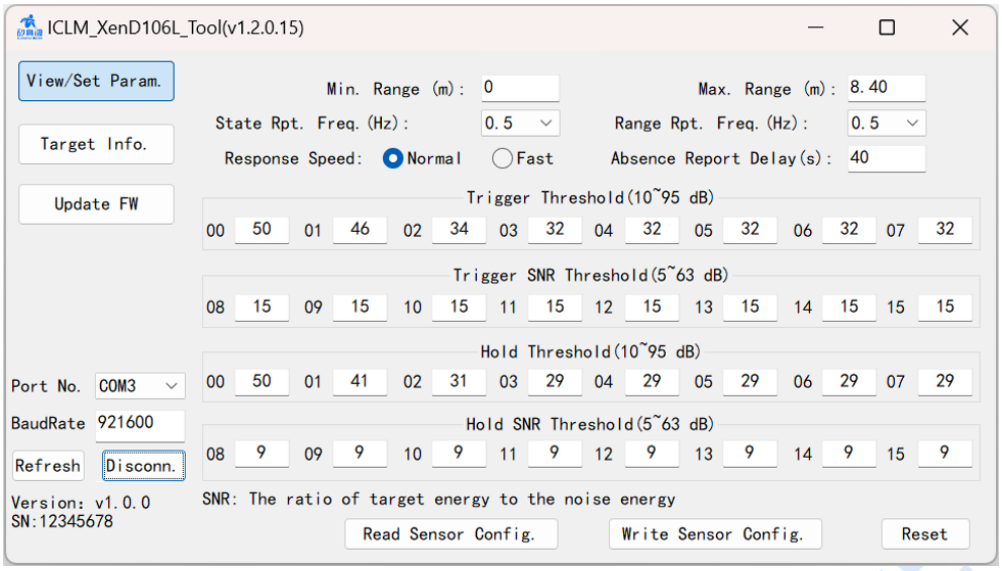
Step 1: Obtain the visualization tool ICLM_XenD106L_Tool from ICLM website.

Step 2: Connect the XenD106L sensor to the host PC according to Figure 4-1.

Step 3: Open the visualization tool, click the **Refresh** button, choose the sensor serial COM number from the drop-box of **Port No.**, and ensure the **BaudRate** is 921600, click the **Connect** button to connect the sensor with the visualization tool.



(a) Before connecting with the sensor



(b) After connecting with the sensor

Figure 4-2 ICLM_XenD106L_Tool

As shown in Figure 4-2 (a), the GUI (graphic user interface) of ICLM_XenD106L_Tool can be partitioned into 3 zones: device operation (Zone1), function buttons (Zone2), and function page (Zone3).

After connecting the visualization tool with the sensor, Zone1 will display the firmware version and the SN (Serial Number, default as 12345678) of the sensor, and the View/Set Parameters function page will display all the parameter setting of the sensor, as shown in Figure 4-2 (b).

4.2.1 View/Set Parameters

The View/Set Param. page of the visualization tool is shown in Figure 4-2. It displays the parameter values of the sensor and enables users to modify each parameter for actual scenarios.

The step for reading sensor parameters is as follows:

Step 1: After connecting the sensor XenD106L with the visualization tool, in the View/Set Param. page, click the Read Sensor Config button, a window writing "Succeed reading parameters" will appear, and the function page will display the parameters of the sensor, click the OK button to close the prompt window.

The steps for setting one or more sensor parameters are listed below:

Step 1: After connecting the sensor XenD106L with the visualization tool, in the View/Set Param. page, type in the new values or select the values from the drop-box for desired parameters;

Step 2: Click the **Set Sensor Config** button, the visualization tool will send all the new values to the sensor, and a prompt window writing "Succeed setting parameters" will appear, click the **OK** button to finish the process.

If users need to reset the sensor's parameters back to the default setting, click the **Reset** button on the View/Set Param. page, and the visualization tool will send the default setting to the sensor and present the default values on the page.

Descriptions of the parameters on the GUI are listed in Table 4-2.

Table 4-2 Descriptions of parameters on GUI

Parameter	Description	Range	Unit
Min. Range	The minimum detectable range of the sensor	0~11.20	m
Max. Range	The maximum detectable range of the sensor	0~11.20	m
State Rpt. Freq.	The frequency of the sensor reporting target status	0.5~8	Hz

Range Rpt. Freq.	The frequency of the sensor reporting target distance when a human target is detected	0.5~8	Hz
Response Speed	The sensor's reaction speed when the target status in the detection area changes from target absence to target presence	Normal/Fast	-
Absence Report Delay	The delay time T before reporting target absence	10~120	s
Trigger Threshold	The definite energy threshold of range gate 0~7 for determining if a human target exists in the corresponding range gate	10~95	dB
Trigger SNR Threshold	The relative SNR threshold of range gate 8~15 for determining if a human target exists the corresponding range gate	5~63	dB
Hold Threshold	The definite energy threshold of range gate 0~7 for determining if a human target is motionless or stays presence in the corresponding range gate	10~95	dB
Hold SNR Threshold	The relative SNR threshold of range gate 8~15 for determining if a human target is motionless or stays presence in the corresponding range gate	5~63	dB

4.2.2 Target Information

The Target Information page displays the human presence detection results and real-time data, as well as operations for saving and replay sensor data.

As shown in Figure 4-3, there are 4 parts in the function page of Target Information page:

- a Detection result presentation zone;
- b Functional buttons zone;
- c Real-time data presentation zone;
- d Save data operating zone.

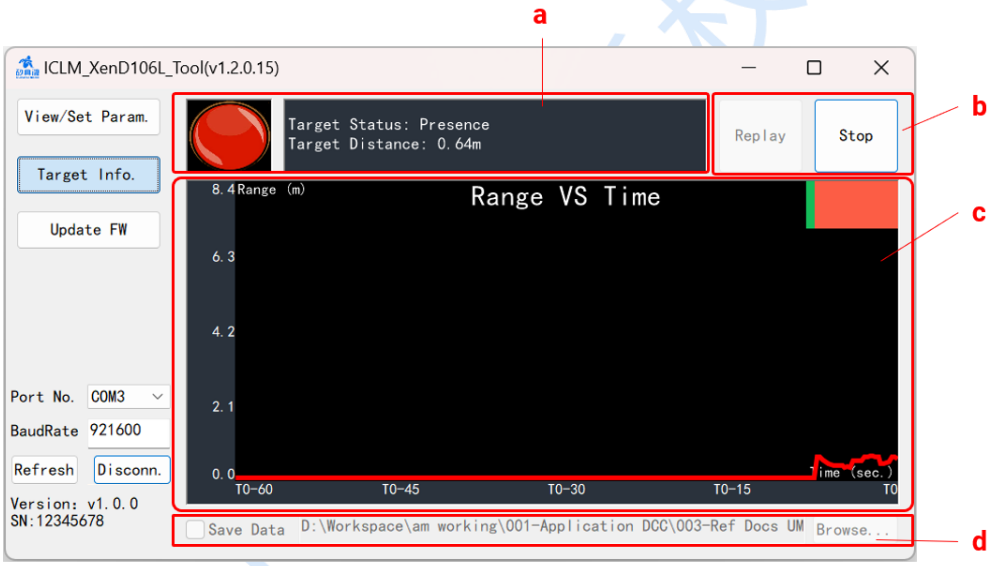


Figure 4-3 The Target Information page

Descriptions of each zone are listed in Table 4-3.

Table 4-3 Description of each zone on Target Information page

Zone		Function	Description
a	Light icon	The color of the light icon represents whether in detection area there is moving or motionless human, or no human presence	Green means no human target is detected; Red means a moving human target is detected; Blue means a motionless human target is detected.
	Target information textbox	Displays the information of the detected target	Displays the moving or presence state of the human target, and the distance between the human target and the sensor (m).

b	Replay/Stop toggle button	To replay or stop the replay the recorded detection data	When the text on the Start/Stop toggle button is Start, this button is clickable.
	Start/Stop toggle button	To start or stop detecting human presence	-
c	Range VS Time presents the detection data in real time	Displays the detected target stated and distance to the sensor in the latest 60 s in real time	The colorful bar on the top presents the target state in real time: green means no human target is detected; red means a moving human target is detected; blue means a motionless human target is detected. The line chart displays the distance between the detected target and the sensor in the latest 60 s.
d	Save detection data	Enable users to decide whether to save the detection data, and to select the desired storage directory.	This zone is only operable when the text on the Start/Stop toggle button is Start; If the Save Data checkbox is ticked, the Browse button turns clickable, and users can select a desired storage directory; if the user does not select the storage directory, the recorded detection data will be saved to the SaveData folder under the same directory of the visualization tool's executable file.

Steps for applying the mmWave sensor and viewing the target information are as follows:

Step 1: After connecting the sensor XenD106L with the visualization tool, click the **Target Information** button to open this function page, the visualization tool will automatically start detecting human presence, with the text on the Start/Stop toggle button displays Stop, and zone a and zone c starts displaying the detected target information in real time;

Step 2: Click the **Start/Stop** toggle button to stop the detection.

Steps for saving the detection data are as follows:

Step 1: After connecting the sensor XenD106L with the visualization tool, click the **Target Information** button to open this function page, the visualization tool will automatically start detecting human presence;

Step 2: Click the **Start/Stop** toggle button to stop the detection, and the text on the Start/Stop toggle button in displays Start, and the save data related functional buttons are operable;

Step 3: Click the checkbox in front of the **Save data** to enable the save data function;

Step 4 (optional): Click the Browse button and select a desired storage directory for the detection data.

Steps for replaying the recorded detection data are as follows:

Step 1: After connecting the sensor XenD106L with the visualization tool, click the **Target Information** button to open this function page, the visualization tool will automatically start detecting human presence;

Step 2: Click the **Start/Stop** toggle button to stop the detection, and the text on the Start/Stop toggle button in displays Start, the Replay/Stop toggle button turns clickable;

Step 3: Click the **Replay/Stop** toggle button, select the recorded detection data file, and the visualization tool starts playing the target information from the detection data, meanwhile the text on the Replay/Stop toggle button is Stop;

Step 4 (Optional): Click the **Replay/Stop** toggle button can stop the replaying; or users can wait till the replay finishes before conducting other operations on the visualization tool.

4.2.3 Update Firmware

The Update FW page is shown in Figure 4-4. The steps for updating sensor firmware are as follows:

Step 1: After connecting the sensor XenD106L with the visualization tool, click the **Update FW** button to open this function page;

Step 2: Click the **Obtain Firmware Info.** button, the firmware and device ID will be displayed under this button, and the text box on the right will display the device ID;

Step 3: Click the **Choose bin file path** button to choose the desired firmware file;

Step 4: Click the **Flash** button to start updating; The text box on the right will display the downloading states, the bin file information, and the downloading progress.

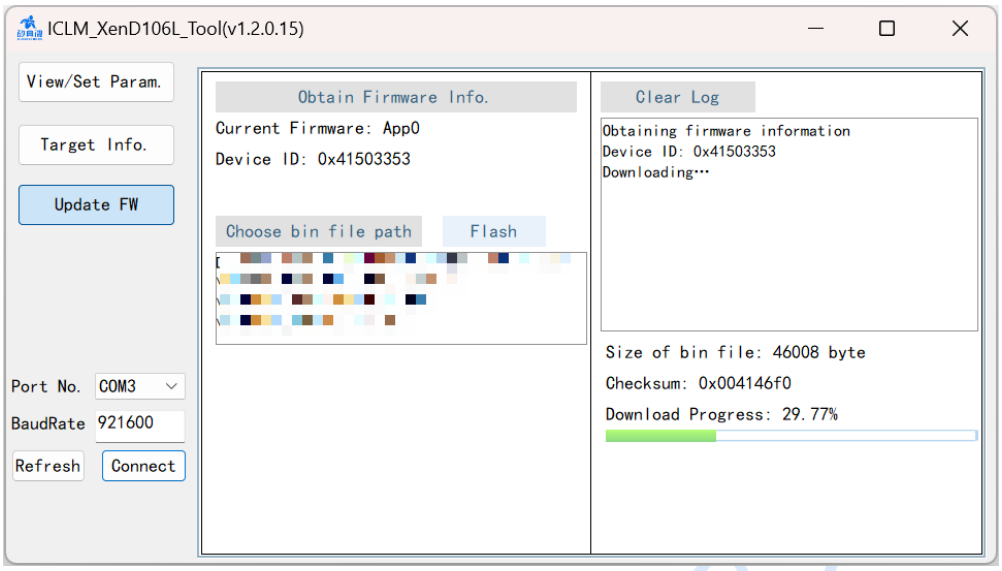


Figure 4-4 The Update Firmware page

After successfully updating the firmware, the text box on the right will print "Download successful!". Otherwise, the text box will print the error message.

5. Communication Protocol

This communication protocol is mainly for users who need to conduct further development without the visualization tool. The battery-operated ultra-low energy human presence detection mmWave sensor XenD106L communicates with the outside via the serial port (TTL). Both the sensor data transfer and parameter configuration follow this protocol. The default serial port baud rate is 921600, with 1 stop bit and no parity bit.

Steps for using commands to configure the sensor are as follows:

1. Enter command mode;
2. Send the command for setting/reading the parameter;
3. Exit command mode.

The XenD106L adopts MSB for data communication, and all the data in the tables of the following sections are hexadecimal.

5.1 Report Data Format

Table 5-1 presents sensor report data format.

Table 5-1 Report data frame format

Header	Intra-frame Data Length	Target State	Target Distance	Reserved	Tailer
F4 F3 F2 F1	2 bytes	1 byte (0/1 means no target; 2/3 means target exists)	2 bytes (cm)	34 bytes	F8 F7 F6 F5

5.2 Command and ACK

5.2.1 Read Firmware Version Command

This command reads the sensor firmware version number.

Command word: 0x0000

Command value: NA

Return value: 2 bytes major revision number + 2 bytes minor revision number + 2 bytes patch revision number

Sending data:

Header	Intra-frame Data Length	Command Word	Tailer
FD FC FB FA	02 00	00 00	04 03 02 01

ACK: (Succeed, Example)

Header	Intra-frame Data Length	Command Word	Major Rev.	Minor Rev.	Patch Rev.	Tailer
FD FC FB FA	08 00	00 01	0x[3] 00	0x 00	0x 00	04 03 02 01

5.2.2 Enable Configuration Command

This command enables the sensor to enter configuration mode. All the other commands should be sent after this command, otherwise the command will be invalid.

Command word: 0x00FF

Command value: 0x0001

Return value: 2 bytes protocol version number (0x0001)

Sending data:

Header	Intra-frame Data Length	Command Word	Command Value	Tailer
FD FC FB FA	04 00	FF 00	01 00	04 03 02 01

ACK(Succeed):

Header	Intra-frame Data Length	Command Word	Protocol Rev.	Tailer
FD FC FB FA	04 00	FF 01	0100	04 03 02 01

5.2.3 End Configuration Command

This command enables the sensor to exit configuration mode. After successfully conducting this command, the sensor will return to normal working mode. If another command needs to be conducted, an Enable Configuration Command needs to be sent beforehand.

Command word: 0x00FE

Command value: NA

Return value: 2 bytes ACK status (0 for success, 1 for failure)

Sending data:

Header	Intra-frame Data Length	Command Word	Tailer
FD FC FB FA	02 00	FE 00	04 03 02 01

[3] In this table, x represents the version number.

ACK(Succeed):

Header	Intra-frame Data Length	Command Word	ACK	Tailer
FD FC FB FA	04 00	FE 01	00 00	04 03 02 01

5.2.4 Write Serial Number Command

This command writes the serial number (SN) into the sensor.

Command word: 0x0010

Command value: 2 bytes Length of SN + 8 bytes SN

Return value: 2 bytes ACK status (0 for success, 1 for failure)

Sending data: (Example: SN is 12345678)

Header	Intra-frame Data Length	Command Word	Length of SN	Serial Number	Tailer
FD FC FB FA	0C 00	10 00	08 00	31 32 33 34 35 36 37 38	04 03 02 01

ACK(Succeed):

Header	Intra-frame Data Length	Command Word	ACK	Tailer
FD FC FB FA	04 00	10 01	00 00	04 03 02 01

5.2.5 Read Serial Number Command

This command reads the sensor serial number.

Command word: 0x0011

Command value: NA

Return value: 2 bytes ACK status (0 for success, 1 for failure) + 2 bytes Length of SN + 8 bytes SN

Sending data:

Header	Intra-frame Data Length	Command Word	Tailer
FD FC FB FA	02 00	11 00	04 03 02 01

ACK(Succeed):

Header	Intra-frame Data Length	Command Word	ACK	Length of SN	Serial Number	Tailer
FD FC FB FA	0E 00	11 01	00 00	08 00	31 32 33 34 35 36 37 38	04 03 02 01

5.2.6 Write General Parameter Command

This command writes the general parameters of the sensor.

Command word: 0x7000

Command value: (2 bytes parameter word + 4 bytes parameter value) * N

Return value: 2 bytes ACK status (0 for success, 1 for failure)

Sending data: (Example: Max. Range Gate[4] = 12; Min. Range Gate = 0; Absence Report Delay (s) = 40; Status Report Frequency[5] = 0.5 Hz; Distance Report Frequency = 0.5 Hz; Response Speed[6] = Normal)

[4] Each range gate represents 0.7 m.

[5] In this protocol, the parameter value of the Status/Distance Report Frequency is the frequency value x 10.

[6] There are two options for Response Speed: Normal and Fast; the parameter value for Normal is 5, Fast is 10.

Header	Intra-frame Data Length	Command Word	Max. Range Gate	Min. Range Gate
FD FC FB FA	26 00	70 00	05 00 0C 00 00 00	0A 00 00 00 00 00

Absence Report Delay (s)	Status Report Frequency	Distance Report Frequency	Response Speed	Tailer
06 00 28 00 00 00	02 00 05 00 00 00	0C 00 05 00 00 00	0B 00 05 00 00 00	04 03 02 01

Sensor ACK (succeed):

Header	Intra-frame Data Length	Command Word	ACK	Tailer
FD FC FB FA	04 00	70 01	00 00	04 03 02 01

Definitions and value ranges of the general parameters are listed in Table 5-2.

Table 5-2 Definitions of general parameter

Parameter Name	Parameter Word	Value Range	Unit
Max. Range Gate	05	0~16	-
Min. Range Gate	0A	0~16	-
Absence Report Delay	06	10 ~ 120	s
Status Report Frequency	02	0.5 ~ 8 (0.5 stepping)	Hz
Distance Report Frequency	0C	0.5 ~ 8 (0.5 stepping)	Hz
Response Speed	0B	5 (Normal) / 10 (Fast)	-

5.2.7 Read General Parameter Command

This command reads the general parameters of the sensor.

Command word: 0x7100

Command value: (2 bytes parameter word) * N

Return value: (4 bytes parameter value) * N

Sending data:

Header	Intra-frame Data Length	Command Word	Max. Range Gate	Min. Range Gate
FD FC FB FA	0E 00	71 00	05 00	0A 00

Absence Report Delay	Status Report Frequency	Distance Report Frequency	Response Speed	Tailer
06 00	02 00	0C 00	0B 00	04 03 02 01

Sensor ACK: (Succeed example:
“Max. Range Gate” = 12; “Min. Range Gate” = 0; “Absence Report Delay (s)” = 40;
“Trigger Report Frequency” = 0.5 Hz; “Hold Report Frequency” = 0.5 Hz)

Header	Intra-frame Data Length	Command Word	ACK	Max. Range Gate	Min. Range Gate
FD FC FB FA	1A 00	71 01	00 00	0C 00 00 00	00 00 00 00

Absence Report Delay	Status Report Frequency	Distance Report Frequency	Response Speed	Tailer
28 00 00 00	05 00 00 00	05 00 00 00	05 00 00 00	04 03 02 01

5.2.8 Write Threshold Parameter Command

This command writes the trigger and hold threshold parameter of the sensor range gate 0~7.

Command Word: 0x7200

Command value: (2 bytes parameter word + 4 bytes parameter value) * N

Return value: 2 bytes ACK (0 for success, 1 for failure)

Sending data: (Example:
Range Gate 0 Trigger Threshold = 50; Range Gate 1 Trigger Threshold = 46;
Range Gate 2 Trigger Threshold = 34; Range Gate 3 Trigger Threshold = 32;
Range Gate 4 Trigger Threshold = 32; Range Gate 5 Trigger Threshold = 32;
Range Gate 6 Trigger Threshold = 32; Range Gate 7 Trigger Threshold = 32;
Range Gate 0 Hold Threshold = 50; Range Gate 1 Hold Threshold = 46;
Range Gate 2 Hold Threshold = 32; Range Gate 3 Hold Threshold = 30;
Range Gate 4 Hold Threshold = 30; Range Gate 5 Hold Threshold = 30;
Range Gate 6 Hold Threshold = 30; Range Gate 7 Hold Threshold = 30)

Header	Intra-frame Data Length	Command Word	Range Gate 0 Trigger Threshold	Range Gate 1 Trigger Threshold	Range Gate 2 Trigger Threshold	Range Gate 3 Trigger Threshold
FD FC FB FA	62 00	72 00	00 00 32 00 00 00	01 00 2E 00 00 00	02 00 2E 00 00 00	03 00 20 00 00 00
Range Gate 4 Trigger Threshold	**Range Gate 5 Trigger Threshold**	**Range Gate 6 Trigger Threshold**	**Range Gate 7 Trigger Threshold**	**Range Gate 0 Hold Threshold**	**Range Gate 1 Hold Threshold**	**Range Gate 2 Hold Threshold**
04 00 20 00 00 00	05 00 20 00 00 00	06 00 20 00 00 00	07 00 20 00 00 00	08 00 32 00 00 00	09 00 2E 00 00 00	0A 00 20 00 00 00
Range Gate 3 Hold Threshold	**Range Gate 4 Hold Threshold**	**Range Gate 5 Hold Threshold**	**Range Gate 6 Hold Threshold**	**Range Gate 7 Hold Threshold**	**Tailer**	
0B 00 1E 00 00 00	0C 00 1E 00 00 00	0D 00 1E 00 00 00	0E 00 1E 00 00 00	0F 00 1E 00 00 00	04 03 02 01	

Sensor ACK (succeed):

Header	Intra-frame Data Length	Command Word	ACK	Tailer
FD FC FB FA	04 00	72 01	00 00	04 03 02 01

Definitions and range values of the trigger threshold and hold threshold of sensor range gate 0~7 are shown in Table 5-3.

Table 5-3 Definitions of sensor trigger and hold threshold

Parameter Name	Parameter Word
Trigger Threshold (range gate 0~ 7)	0~7
Hold Threshold (range gate 0~ 7)	8~15

5.2.9 Read Threshold Parameter Command

This command reads the trigger and hold threshold parameter of the sensor range gate 0~7.

Command Word: 0x7300

Command value: (2 bytes parameter word) * N

Return value: (4 bytes parameter value) * N

Sending data:

Header	Intra-frame Data Length	Command Word	Range Gate 0 rigger Threshold	Range Gate 1 rigger Threshold	Range Gate 2 Trigger Threshold	Range Gate 3 Trigger Threshold
FD FC FB FA	22 00	73 00	00 00	01 00	02 00	03 00
Range Gate 4 Trigger Threshold	**Range Gate 5 Trigger Threshold**	**Range Gate 6 Trigger Threshold**	**Range Gate 7 Trigger Threshold**	**Range Gate 0 Hold Threshold**	**Range Gate 1 Hold Threshold**	**Range Gate 2 Hold Threshold**
04 00	05 00	06 00	07 00	08 00	09 00	0A 00
Range Gate 3 Hold Threshold	**Range Gate 4 Hold Threshold**	**Range Gate 5 Hold Threshold**	**Range Gate 6 Hold Threshold**	**Range Gate 7 Hold Threshold**	**Tailer**	
0B 00	0C 00	0D 00	0E 00	0F 00	04 03 02 01	

Sensor ACK(succeed): (Example:

Range Gate 0 Trigger Threshold = 50; Range Gate 1 Trigger Threshold = 46;
Range Gate 2 Trigger Threshold = 34; Range Gate 3Trigger Threshold = 32;
Range Gate 4Trigger Threshold = 32; Range Gate 5 Trigger Threshold = 32;
Range Gate 6 Trigger Threshold = 32; Range Gate 7 Trigger Threshold = 32;
Range Gate 0 Hold Threshold = 50; Range Gate 1 Hold Threshold = 46;
Range Gate 2 Hold Threshold = 32; Range Gate 3 Hold Threshold = 30;
Range Gate 4 Hold Threshold = 30; Range Gate 5 Hold Threshold = 30;
Range Gate 6 Hold Threshold = 30; Range Gate 7 Hold Threshold = 30)

Header	Intra-frame Data Length	Command Word	ACK	Range Gate 0 Trigger Threshold	Range Gate 1 Trigger Threshold	Range Gate 2 Trigger Threshold
FD FC FB FA	44 00	73 01	00 00	32 00 00 00	2E 00 00 00	22 00 00 00
Range Gate 3 Trigger Threshold	**Range Gate 4 Trigger Threshold**	**Range Gate 5 Trigger Threshold**	**Range Gate 6 Trigger Threshold**	**Range Gate 7 Trigger Threshold**	**Range Gate 0 Hold Threshold**	**Range Gate 1 Hold Threshold**
20 00 00 00	20 00 00 00	20 00 00 00	20 00 00 00	20 00 00 00	32 00 00 00	2E 00 00 00
Range Gate 2 Hold Threshold	**Range Gate 3 Hold Threshold**	**Range Gate 4 Hold Threshold**	**Range Gate 5 Hold Threshold**	**Range Gate 6 Hold Threshold**	**Range Gate 7 Hold Threshold**	**Tailer**
20 00 00 00	1E 00 00 00	1E 00 00 00	1E 00 00 00	1E 00 00 00	1E 00 00 00	04 03 02 01

5.2.10 Write SNR Parameter Command

This command writes the trigger and hold SNR parameters of the sensor.

Command Word: 0x7400

Command value: (2 bytes parameter word + 4 bytes parameter value) * N

Return value: 2 bytes ACK (0 for success, 1 for failure)

Sending data: (Example:

Range Gate 08 Trigger SNR=15; Range Gate 09 Trigger SNR= 15;
Range Gate 10 Trigger SNR= 15; Range Gate 11 Trigger SNR= 15;
Range Gate 12 Trigger SNR= 15; Range Gate 13 Trigger SNR= 15;
Range Gate 14 Trigger SNR= 15; Range Gate 15 Trigger SNR= 15;
Range Gate 08 Hold SNR= 09; Range Gate 09 Hold SNR= 09;
Range Gate 10 Hold SNR= 09; Range Gate 11 Hold SNR= 09;
Range Gate 12 Hold SNR= 09; Range Gate 13 Hold SNR= 09;
Range Gate 14 Hold SNR= 09; Range Gate 15 Hold SNR= 09)

Header	Intra-frame Data Length	Command Word	Range Gate 8 Trigger SNR	Range Gate 9 Trigger SNR	Range Gate 10 Trigger SNR	Range Gate 11 Trigger SNR
FD FC FB FA	62 00	74 00	00 00 0F 00 00 00	01 00 0F 00 00 00	02 00 0F 00 00 00	03 00 0F 00 00 00
Range Gate 12 Trigger SNR	**Range Gate 13 Trigger SNR**	**Range Gate 14 Trigger SNR**	**Range Gate 15 Trigger SNR**	**Range Gate 8 Hold SNR**	**Range Gate 9 Hold SNR**	**Range Gate 10 Hold SNR**
04 00 0F 00 00 00	05 00 0F 00 00 00	06 00 0F 00 00 00	07 00 0F 00 00 00	08 00 09 00 00 00	09 00 09 00 00 00	0A 00 09 00 00 00
Range Gate 11 Hold SNR	**Range Gate 12 Hold SNR**	**Range Gate 13 Hold SNR**	**Range Gate 14 Hold SNR**	**Range Gate 15 Hold SNR**	**Tailer**	
0B 00 09 00 00 00	0C 00 09 00 00 00	0D 00 09 00 00 00	0E 00 09 00 00 00	0F 00 09 00 00 00	04 03 02 01	

Sensor ACK (succeed):

Header	Intra-frame Data Length	Command Word	ACK	Tailer
FD FC FB FA	04 00	74 01	00 00	04 03 02 01

Definitions of the parameter word of trigger/hold SNR for sensor range gate 8~15 are presented in Table 5-4.

Table 5-4 Definitions of the parameter word of trigger/hold SNR

Parameter Name	Parameter Word
Trigger SNR (range gate 8~15)	0~7
Hold SNR (range gate 8~15)	8~15

5.2.11 Read SNR Parameter Command

This command reads the trigger and hold SNR parameters of the sensor.

Command Word: 0x7500

Command value: (2 bytes parameter word) * N

Return value: (4 bytes parameter value) * N

Sending data:

Header	Intra-frame Data Length	Command Word	Range Gate 8 Trigger SNR	Range Gate 9 Trigger SNR	Range Gate 10 Trigger SNR	Range Gate 11 Trigger SNR
FD FC FB FA	22 00	75 00	00 00	01 00	02 00	03 00
Range Gate 12 Trigger SNR	**Range Gate 13 Trigger SNR**	**Range Gate 14 Trigger SNR**	**Range Gate 15 Trigger SNR**	**Range Gate 8 Hold SNR**	**Range Gate 9 Hold SNR**	**Range Gate 10 Hold SNR**
04 00	05 00	06 00	07 00	08 00	09 00	0A 00
Range Gate 11 Hold SNR	**Range Gate 12 Hold SNR**	**Range Gate 13 Hold SNR**	**Range Gate 14 Hold SNR**	**Range Gate 15 Hold SNR**	**Tailer**	
0B 00	0C 00	0D 00	0E 00	0F 00	04 03 02 01	

Sensor ACK(succeed): (Example:

Range Gate 8 Trigger SNR=15; Range Gate 9 Trigger SNR= 15;
Range Gate 10 Trigger SNR= 15; Range Gate 11 Trigger SNR= 15;
Range Gate 12 Trigger SNR= 15; Range Gate 13 Trigger SNR= 15;
Range Gate 14 Trigger SNR= 15; Range Gate 15 Trigger SNR= 15;
Range Gate 8 Hold SNR= 09; Range Gate 9 Hold SNR= 09;
Range Gate 10 Hold SNR= 09; Range Gate 11 Hold SNR= 09;

Range Gate 12 Hold SNR= 09; Range Gate 13 Hold SNR= 09;
Range Gate 14 Hold SNR= 09; Range Gate 15 Hold SNR= 09)

Header	Intra-frame Data Length	Command Word	ACK	Range Gate 8 Trigger SNR	Range Gate 9 Trigger SNR	Range Gate 10 Trigger SNR
FD FC FB FA	44 00	75 01	00 00	0F 00 00 00	0F 00 00 00	0F 00 00 00
Range Gate 11 Trigger SNR	**Range Gate 12 Trigger SNR**	**Range Gate 13 Trigger SNR**	**Range Gate 14 Trigger SNR**	**Range Gate 15 Trigger SNR**	**Range Gate 8 Hold SNR**	**Range Gate 9 Hold SNR**
0F 00 00 00	0F 00 00 00	0F 00 00 00	0F 00 00 00	0F 00 00 00	09 00 00 00	09 00 00 00
Range Gate 10 Hold SNR	**Range Gate 11 Hold SNR**	**Range Gate 12 Hold SNR**	**Range Gate 13 Hold SNR**	**Range Gate 14 Hold SNR**	**Range Gate 15 Hold SNR**	**Tailer**
09 00 00 00	09 00 00 00	09 00 00 00	09 00 00 00	09 00 00 00	09 00 00 00	04 03 02 01

6. Installation and Detection Range

The recommended installation method of sensor XenD106L is wall-mounted installation, and sensor relative directions are shown in Figure 6-1. The direction of X axis is defined as 0°, Z axis is defined as 90°, and Y axis is perpendicular to X-Z plane (also known as normal direction).

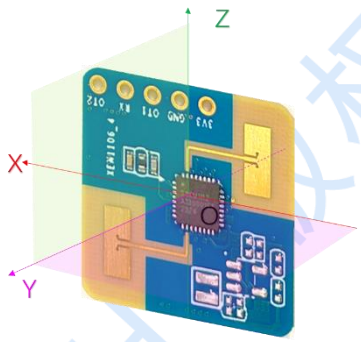


Figure 6-1 Illustration of sensor relative directions

The recommended installation height for wall mounting method is 1.5 m ~ 2.0 m. The motion detection range of sensor XenD106L under default setting is a cone shaped area with a radius of 8 m, azimuth and pitch angle of ±60°, as shown in Figure 6-2.

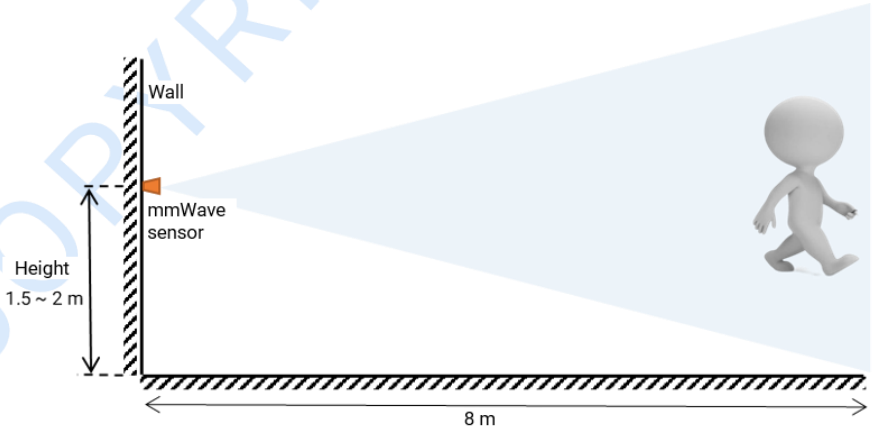


Figure 6-2 Illustration of XenD106L detection range (wall mounted)

Detailed detection ranges of motionless, micro-moving and moving human target in various directions are shown in Figure 6-3, when sensor XenD106L is wall mounted with the height of 1.5 m.

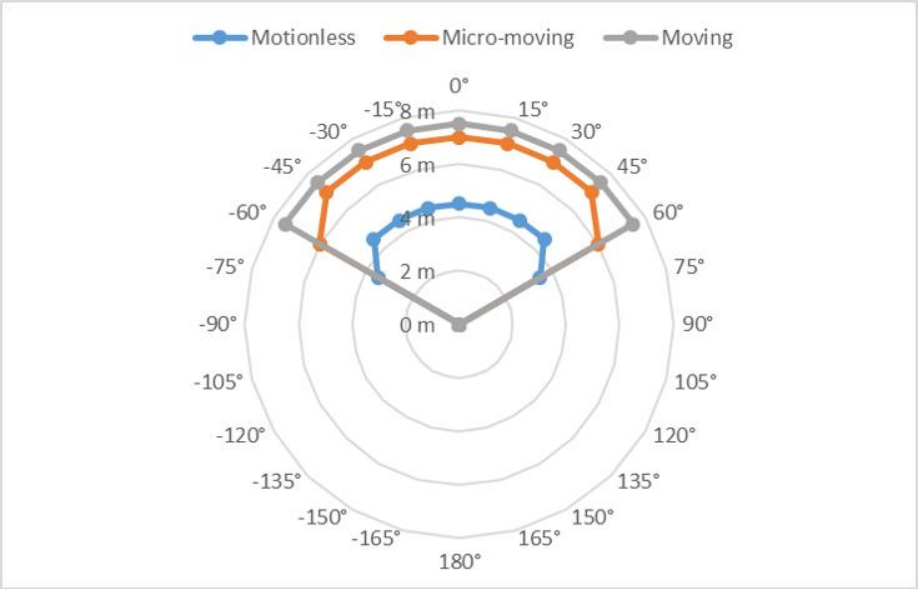


Figure 6-3 Detection range of wall mounted XenD106L

7. Mechanical Size

Figure 7-1 presents the mechanical size of hardware Xen106, all the unit is mm. The board thickness is 1.2 mm with a tolerance of ±10%.

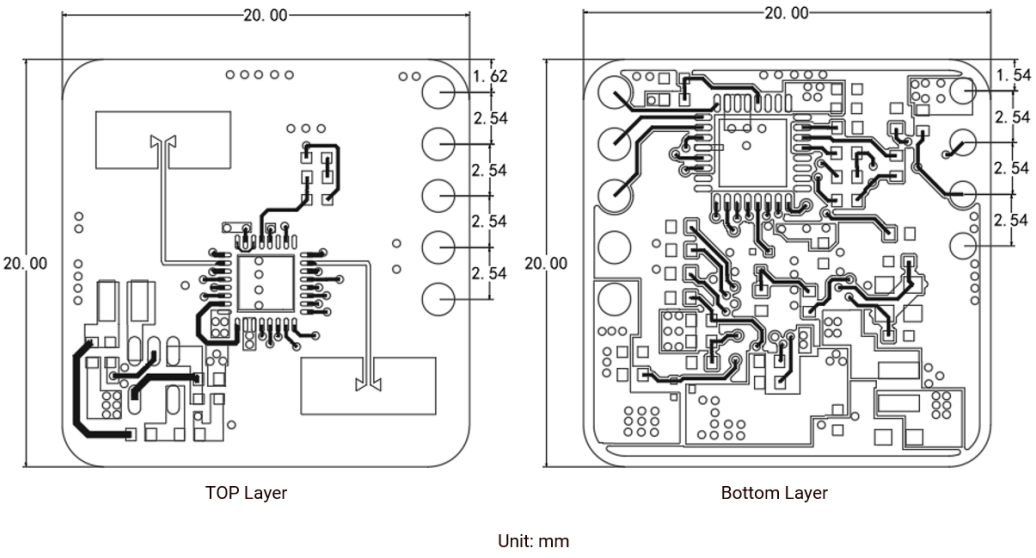


Figure 7-1 Hardware Xen106 mechanical size

8. Installation Requirement

Radome Requirements

If there is a need to install a radome, the radome material must have good transparency for 24 GHz, and do not contain any material that may block electromagnetic wave such as metal. More details please refer to

Guide of mmWave Sensor Antenna Radome Design[7] .

Installation Environment

When installing the product, certain requirements should be taken into consideration in case the detection performance is interfered. Features of unsuitable environment are listed below.

- Continuous moving non-human objects in detection area, such as moving animals, swinging curtains, big shaking plants in front of an active vent etc.
- Large strong reflectors will interfere with detection performance when put in front of the antennas.
- Interferences of on-ceiling home appliances such as air-conditioners, fans, etc. should be taken into consideration while top mounted.

Important Requirements

- Ensure the antennas are facing squarely to desired detection area with a clear field of view.
- Ensure the installation position of the sensor is solid and stable. Motion of the sensor itself can hugely impact signal processing.
- Ensure there is no object moving or vibrating behind the sensor. Motion behind antennas can also be detected due to the penetrability of RF wave, thus it interferes the detection accuracy. It is recommended to use a radome or a backplane to reduce the interference.
- When there are multiple 24 GHz sensors installed nearby, ensure their beamforms do not face to each other, try to separate them as far as possible to avoid interference.

Power Supply

XenD106L supports power supply ranging from 3.3 V to 3.6 V, and the power ripple should show no obvious spectral peaks within 100 kHz. Additionally, developers should take EMC design such as ESD and lightning surge into consideration.

9. Important Tips

Maximum Detection Range

The maximum detection range of sensor XenD106L is 8 m in radical direction. Within this range, the sensor reports the direct distance of the detected moving target.

Modifying Firmware Baud Rate

The default baud rate of sensor XenD106L is 921600. It can be modified through the macro USART0_BAUDRATE defined under engineering directory \platform\py32\inc\py32_uart.h.

Maximum Detection Range and Range Accuracy

Theoretically, the range measurement error of sensor XenD106L is ±0.35 cm. However, the value together with the maximum range may vary according to human target size, pose, and RCS.

Absence Report Delay

When human absence is detected in detection area, the sensor will delay the absence report. The delay mechanism works as such: once no human target is detected in detection area, the sensor will start a timer whose duration is the parameter absence report delay, and if there is no target showing up during this timing the sensor will end the timer and send the non-human report; however, if a human target is detected in detection area during the timing, the sensor will end and refresh the timer before sending the target information.

[7] Currently, only Chinese version is available.

10. Revision History

Revision	Date	Modification
1.0	2023/10/20	Initial release.

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